RELIABLEPLANT 2016
CONFERENCE & EXHIBITION

Catching contamination and mislabeling of fresh lubricants

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Outline

- **Do you really have the right lubricant?**
  - Contamination • Comingling • Mislabeling
  - Use of improper lubricants can lead to equipment performance degradation or failure

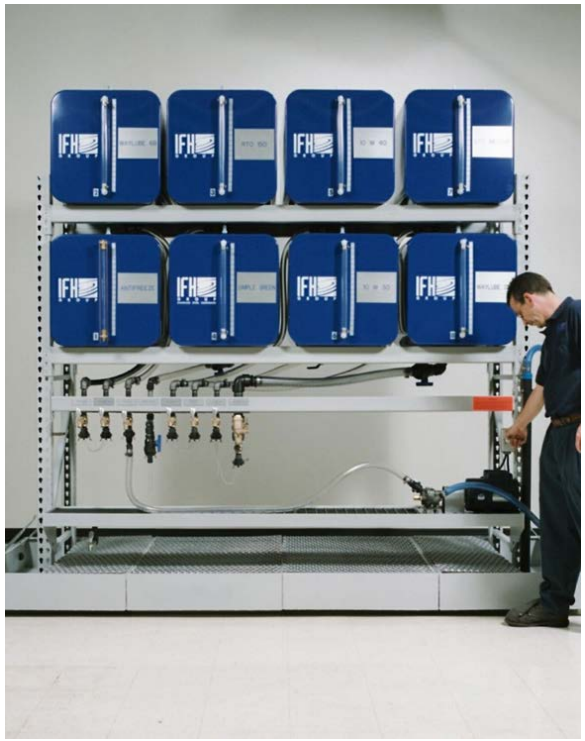
- **How can I detect a wrong lubricant BEFORE it creates a problem?**
  - Viscosity is the most sensitive physical property
  - Using the product certificate of analysis (COA)
  - Relying on the product viscosity-grade specifications
  - Using a new class of field-capable viscometers

Overview of the Problem

- Lubricants pass through many hands
- Conveyance systems and containers
- From manufacturer → supplier →end user

Overview of the Problem

- Tracing the trail of the lubricant can be difficult
- Multiple off-loadings and transfers leave many chances for contamination, comingling and uncertainty
  - Tanks
  - Transfer Lines
  - Pumps & Filters
  - Drums & Totes
  - Mislabeled Containers



Overview of the Problem

- Many manufacturers and distributors use dedicated lines and tanks for each lubricant product
- However, some do not and those lines and tanks must be cleaned when switching from one product to the next
- The process of cleaning involves passing flush oil through the lines to ensure that what follows is not contaminated by the previous product
- “Line Flushing” is not an exact science and can lead to cross-contaminated or commingled lubricants

Overview of the Problem

- Lubricants are complex blends of base oils and specialty additives required to meet stringent performance specs
  - ISO VG Industrial Lubricants
  - SAE Motor Oils
  - SAE Gear Oils
  - Hydraulic Fluids
- Each class of lubricant has multiple grades primarily differing by viscosity, such as:
  - 5W-30, 10W-40, 15W-40…
  - ISO VG 32, 46, 68…

Classes of various lubricants are intended for different purposes and are often not compatible with one another due to differences in additive chemistries. Oil ≠ Oil

Overview of the Problem

- Lubricants must meet stringent specifications
  - American Society of Testing and Materials (ASTM)
  - Society of Automotive Engineers (SAE)
  - International Standards Organizations (ISO)
- Specify the exact physical property limits for each grade along with the appropriate laboratory test method and type of instrumentation required to be used.
- Other than numbers on a table or test report, most lubricants are visibly indiscernible from one another.

Overview of the Problem

- Formulated lubricants have complex blend chemistries
- Whether it is an ISO VG industrial lubricant, SAE automotive or heavy-duty engine oil, or gear oil, there is more than just simple base oil in the blend.
- Most contain a multitude of additives for
  - improving low temperature flow ability
  - anti-foam and corrosion inhibitors
  - high-temperature stability of viscosity and oxidation
- And they often are not compatible with one another when comingled together.

Overview of the Problem

- Most bulk and industrial deliveries of oil are accompanied by a Certificate of Analysis (COA)
  - American Petroleum Institute (API) Standard 1525A
  - Requires Chain-of-Custody Documentation and COA
- Lubricant manufacturers test the oil in their laboratories and create the COA
- Confirms the oil meets the required specification BEFORE it is transferred to the distributor.

Example Certificate of Analysis

Certificate of Analysis

XYZ OIL Petroleum Distributor 100 Main Street Philadelphia, PA 19116	Customer Order: 8046214 Shipped Quantity: 6,468.00 GAL Shipped From: PHILA RAILROAD ST PLANT Order Number: 9566864/000011 Date Shipped: September 16, 2015 Sold To Number: 813362

Brand X PC 5W-30 BULK
PREMIUM CONVENTIONAL SAE 5W-30 MOTOR OIL
Manufacturer Material Number: WW1912
Customer Material Number: WW1912 Batch: 6813

Characteristics	Specification	Results
Appearance	Clear & Bright	Clear & Bright
Density @ 15°C (g/mL) – ASTM D4052		0.8557
Density @ 15°C (lb/gal) – ASTM D4052		7.1412
Kinematic Viscosity @ 40°C (cSt) – ASTM D445	11.0 – 11.7	11.2
Kinematic Viscosity @ 100°C (cSt) – ASTM D445	55.0 – 75.0	67.4
Cold-Cranking Simulator @ -30°C (cP) – ASTM D5293	5400 - 6600	6237
Pour Point (°C) – ASTM D5949/5950	<= -36	-45
Calcium (%m) – ASTM D4951	0.1460 – 0.1840	0.1647
Phosphorus (%m) – ASTM D4951	0.0680 – 0.0800	0.0711
Sodium (%m) – ASTM D4951	0.0420 – 0.0540	0.0451
Zinc (%m) – ASTM D4951	0.0750 – 0.0910	0.0876
NOACK Volatility (%) – ASTM D5800B	<= 14.5	12.9
Date of Manufacture		September 14, 2015
Shipped Quantity		6,468.00 GAL

Notes:

Responsible Manufacturing Facility:
Brand X
Affiliate of Lubricant XYZ Corp.
200 Railroad Street
Philadelphia, PA 19105

Quality Contact:
Robert Smith
Quality Supervisor
Phone: (123) 456-7899
Fax: (123) 456-7899

This COA is printed from a secure computer system ensuring the batch was properly released by the Quality Department and is valid without signature. Statement of the above data does not release the buyer from his legal obligation to examine the material on receipt.

ISO 9001-2008 registered firm

Finding the Solution

- Most oils are visibly similar,
  other than the relative thickness or viscosity
- Or the same oil from different lots may vary in color.

- How can a service technician
  reliably know they have
  the proper lubricant
  …BEFORE they install it?

Finding the Solution

- The only reliable method for determining if the lubricant is correct… is to compare the lubricant **viscosity** against its original viscosity specification.
- SAE J300 Specification table for Multi-grade engine oils with the kinematic viscosity limits at 100 °C the typical engine operating temperature

SAE J300 Multi-grade Engine Oil	Minimum Kinematic Viscosity in mm^2/s at 100 °C	Maximum Kinematic Viscosity in mm^2/s at 100 °C
xW-16	6.1	<8.2
xW-20	6.9	<9.3
xW-30	9.3	<12.5
xW40	12.5	<16.3
xW-50	16.3	<21.9
xW-60	21.9	<26.1
Note: "x" denotes either 0, 5, 10, 15, 20, or 25 as in 0W-5, 5W-30, 15W-40.		

Finding the Solution

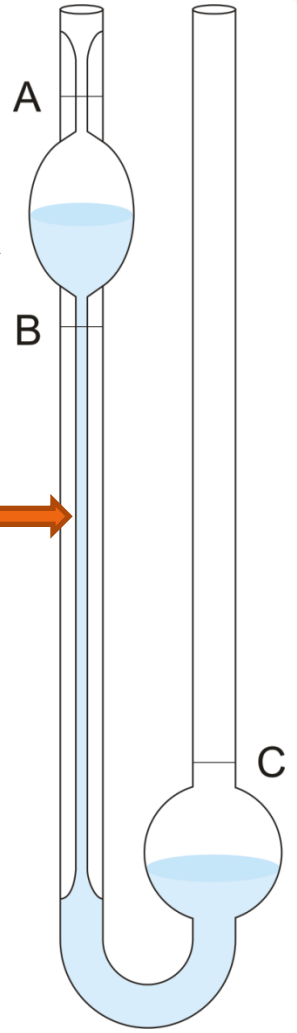
- Formulated lubricants must meet multiple physical property specifications when manufactured.
- These properties vary by the lubricant use, purpose and grade.
- Properties such as kinematic viscosity, density, flash point and pour point are among the most common.
- Of these, nothing is more sensitive to small amounts of contamination than kinematic viscosity - making it the parameter of choice when discriminating whether or not a product “is what it says it is.”

So What Exactly is Viscosity?

- Viscosity is a physical property of a fluid that defines its resistance to want to flow under specified conditions
  - temperature of the fluid
  - amount and type of force applied to cause it to move
- In a gearbox, this might be the pressure between two mating gear teeth attempting to push the oil out of the way while the gear box is at operating temperature
- Kinematic viscosity is the measure of the fluids resistance to flow under the influence or force of gravity
- Kinematic viscosity uses the units of Centistoke (cSt) or mm^2/s

What is Viscosity?

- A typical kinematic viscometer consists of a capillary tube connected to a reservoir
- Viscosity is determined by measuring the amount of time required for a fixed volume of oil to flow through a capillary restriction beneath it. Timing the flow as it passes from point A to point B
- Low viscosity fluids flow quickly (less time) while high viscosity fluids flow more slowly
- Kinematic Viscosity = Flow Time x Calibration Constant of the viscometer



Finding the Solution

- Most lubricants are graded by kinematic viscosity
- There is spacing between grades that allows for discrimination of an incorrect lubricant simply by determining if the viscosity is within the limits for its grade.
- No other physical property specification for lubricants affords such an opportunity to catch an error.

ISO VG Oil Viscosity Limits by Grade

- **Viscosity specified at 40 °C the typical service temp.**

ISO Viscosity Grade Oil	Minimum Kinematic Viscosity in mm^2/s at 40 °C	Maximum Kinematic Viscosity in mm^2/s at 40 °C
ISO VG 2	1.98	2.42
ISO VG 3	2.88	3.52
ISO VG 5	4.14	5.06
ISO VG 7	6.12	7.46
ISO VG 10	9.00	11.0
ISO VG 15	13.5	16.5
ISO VG 22	19.8	24.2
ISO VG 32	29.8	35.2
ISO VG 46	41.4	50.6
ISO VG 68	61.2	74.8
ISO VG 100	90.0	110
ISO VG 150	135	165
ISO VG 220	198	242
ISO VG 320	288	352
ISO VG 460	414	506
ISO VG 680	612	748
ISO VG 1000	900	1100
ISO VG 1500	1350	1650
ISO VG 2200	1980	2420
ISO VG 3200	2880	3520
Note: ISO VG 10 through ISO VG 680 are the most widely used in industrial applications		

Selecting the Proper Temperature

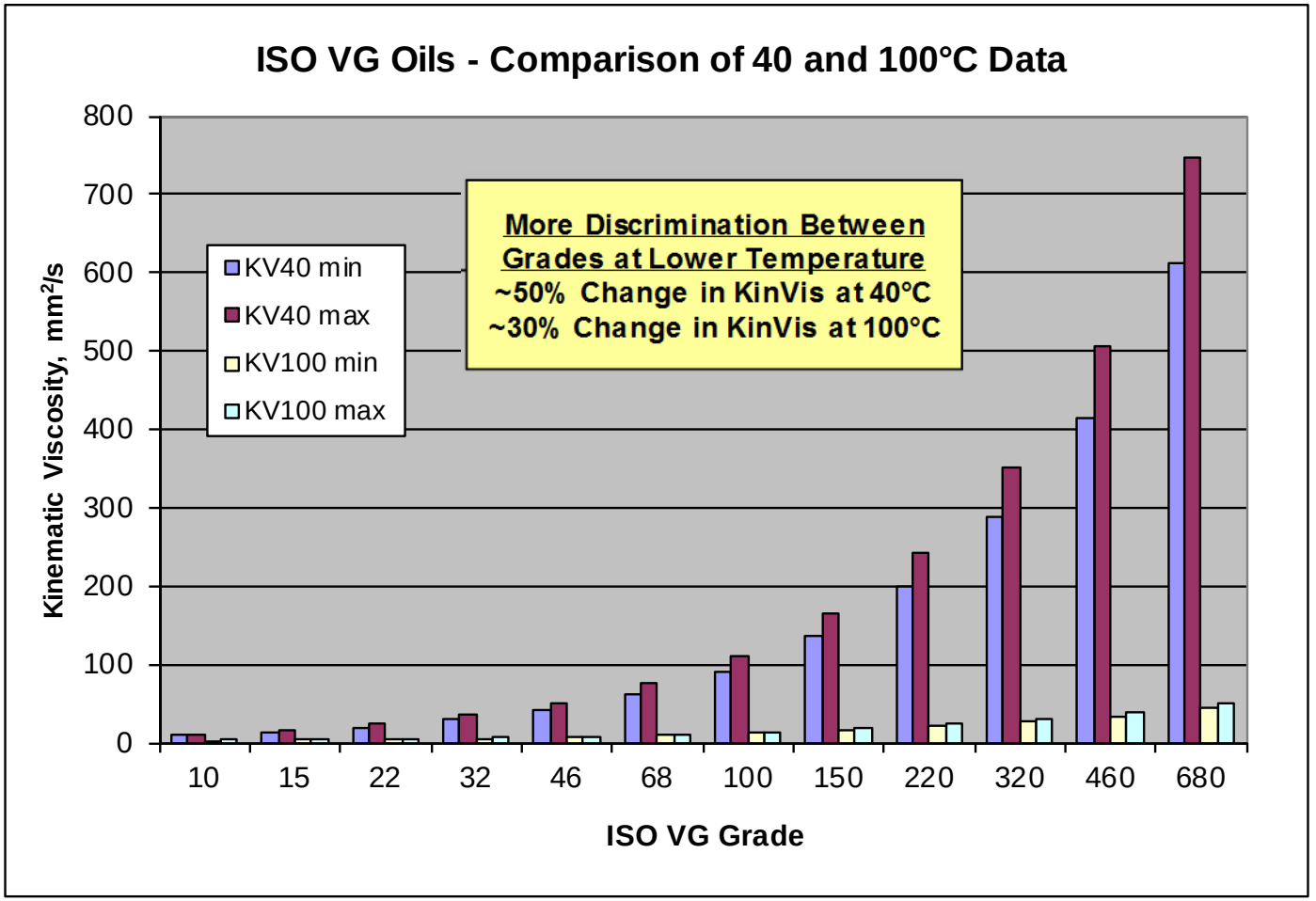
- The viscosity of petroleum increases as the temperature decreases
- When looking at the viscosity of ISO VG lubricants, the amount of difference in viscosity between adjacent oil grades is
  - approximately 50% at 40°C
  - decreases to only 30% at 100°C
- The difference in minimum kinematic viscosity between ISO VG 100 and ISO VG 150 oils at 40 °C is 45 cSt (50%) while at 100 °C the difference decreases to 3.90 cSt (33%).

ISO VG Kinematic Viscosity Limits at 40 °C and 100 °C

ISO VG Grade	KinVis, mm^2/s			
	Specification		Calculated*	
	40 °C		100 °C	
	min	max	min	max
2	1.98	2.42	~0.50	
3	2.88	3.52	~1.00	
5	4.14	5.06	~1.50	
7	6.12	7.46	2.00	2.28
10	9.00	11.00	2.58	2.93
15	13.50	16.50	3.34	3.78
22	19.80	24.20	4.24	4.79
32	29.80	35.20	5.34	6.09
46	41.40	50.60	6.79	7.77
68	61.20	74.80	8.86	10.23
100	90.00	110.00	11.68	13.47
150	135.00	165.00	15.58	17.93
220	198.00	242.00	20.35	23.38
320	288.00	352.00	26.38	30.34
460	414.00	506.00	33.93	38.93
680	612.00	748.00	44.29	50.67
1000	900.00	1100.00	57.34	65.45
1500	1350.00	1650.00	74.82	85.15
2200	1980.00	2420.00	95.70	108.60
3200	2880.00	3520.00	121.05	136.90

** Assuming a VI of 120*

Comparison of ISO VG Grades by Temp.



Selecting the Proper Temperature

- The wider the separation of viscosity between the grades, the greater the chance of determining exactly the grade of lubricant
- For ISO VG oils, the recommended temperature is the specification temperature of 40°C
- Provides the best condition for detecting when most lubricants are out of specification or “out of grade” because the differences in viscosity (separation) between adjacent grades are the largest at that temperature.

Finding the Solution

- To check a lubricant against its COA for **all** specification properties would require most industrial users to send the oil to a third-party testing laboratory.
- A timely and costly proposition with multiple lubricants
- Checking the lubricant against just its viscosity specification would allow the user to determine if a lubricant was the proper grade or not.
- Viscosity won't answer the question of how it was contaminated or mislabeled – but it will determine if the product is not the proper grade

Finding the Solution

- Making accurate field measurements of viscosity has long been a challenge for industrial lubricant users
- Accurate viscosity measurement has traditionally only come from sensitive and expensive laboratory instruments.
- The lube oil industry relies on a standardized test methodology (ASTM D445) for determining the viscosity of lubricants throughout the formulary design, blending, and bottling processes.
- D445 viscometers are expensive and require laboratory environments and trained technicians to operate

Finding the Solution

- Most industrial users don't have laboratories or the capital to invest in laboratory grade instruments
- They don't have trained laboratory staff either
- Simplistic viscosity comparators have always had accuracy limitations—insufficient for detecting even moderate differences in viscosity

Finding the Solution

- Much of the inaccuracy in a comparator-type viscometer stems from a lack of thermal control of the sample
- The reference fluid (often a base oil) differs from the formulated lubricant being compared against.
- The viscosity of petroleum products is very sensitive to even small changes in temperature
  - viscosity changes by 2% per 1°C change in temperature
- This rate of change (or slope of viscosity versus temperature) is defined by ASTM as the Viscosity Index (or simply the oils' VI)

Finding the Solution

- Most industrial ISO VG lubricants have a VI of 100-120
- While modern engine oils can have a VI of 150 or greater – with some synthetics having VI's of 250.
- Oils with the higher VI numbers will have larger changes in viscosity as the temperature changes.
- Measurement error in a viscosity comparator increases greatly as the difference in VI increases between the reference fluid and the sample being tested.

Finding the Solution

- All this has changed with a new class of fast, accurate and easy-to-use field-capable viscometers
- Built-in temperature management of the sample to precise temperatures at 40°C or 100°C ±0.05 °C
- Now lubricant distributors, plant maintenance personnel and field service technicians have an affordable new tool to answer the question “is it what it says it is?”

Conclusion

- Knowing what lubricant is being installed in a piece of machinery is paramount to the machines health
- The chances of having the wrong lubricant or a different grade in a drum or container is a real-world problem
- Only field testing of viscosity can answer the question

  "is it what it says it is"
- New field-capable viscometers can simply, quickly, and accurately test viscosity BEFORE it is installed